A review on Design & navigation techniques of Automated Guided Vehicles systems (AGVs)

[1]Rushikesh Dave, [2]Saurin Sheth,

[1]Student in Master of Engineering, daverushikesh5@gmail.com, [2]Associate Professor
[1]Mechatronics,
[1]G. H. Patel College of Engineering & Technology, Vallabh Vidhyanagar, India

Abstract : Currently there are so many types of industries that are using altered types of material handling techniques. Among these techniques automated guided vehicles are one of the best options if the pickup and drop point for moving material are fixed. This paper presents the design of AGVs that are currently developed. We discuss some navigation techniques by which AGVs are operated also discussion of parts used for developing AGV is given. Respective application of AGVs at places as well as we present some idea for application of AGVs at other places.

Keywords: Automated Guided Vehicle system, AGVs, Design, Navigation techniques, control system

I. INTRODUCTION

Automated Guided Vehicles (AGVs) are one of the most sensational and active areas for material handling work today. Automated Guided Vehicles can be driverless computer controlled or remote-controlled mobile vehicles that operates automatically beside pathways with either in-floor wiring or others convenient options such as fluorescent stripes, optical scanning of various markings or other navigation techniques. Through the years the technological developments essentially in electronics and robotics, have offered Automated Guided Vehicles numerous advantages over other material handling operations, some of them are as follow, routing flexibility in fleet, reliability of work, low operating costs under facility, obstacle free motion as well as easy incorporation with other systems. The varieties in configurations of Automated Guided Vehicles are endless. Which implies virtually any type of mobile material handling paraphernalia can be adapted to an Automated Guided Vehicle. In the past decades, many researchers have dedicated their work to the technology of Automated Guided Vehicles systems [1], [2], [3]. Numbers of AGVs have been manufactured around the world that are currently being used in numerous material handling jobs. So many researchers has addressed several formulations of calibration problems for different robotic systems such as Automated Guided vehicles, including the calibration of multi-sensor systems [4-10].

An automated guided vehicle is a programmable mobile robot vehicle that follows instruction on either repeat base or singularly. The automated guided vehicle are capable of carrying materials fully automatically at low expanses. Automated guided vehicle have to make the system automatic by following proper navigation techniques with help of decision on the path selection. The central processing system of automated guided vehicle controls the steering, direction and speed of AGV. For material handling pre-defined map is saved in microcontroller's memory to navigate around facility. A general automated guided vehicle (AGV) system essentially consists of onsite component as well as stationary control system over it. The main components to develop AGV system are

- Design of Vehicle
- Control System
- Navigation Techniques

The task that required to perform depends on these components of AGV. This paper mainly focus on this three components of AGV. First section of the paper gives introduction to AGV. Second section deals with design of AGVs that are developed by researchers and some existing AGVs at industries. Third section Gives information of control system of AGVs and parts used for control. Fourth section gives brief information of navigation techniques used by AGV to move around facility. This section also presents existing and alternative application of AGVs in industries as well as service places.

II. AGV DESIGNS

The design of AGV express a big role in tasks required to perform. The central elements of vehicle performs the actual transportation task. Other elements are used as either input signal elements or actuation of AGV. This all elements fits with center element and combination of all elements leads to actual AGV task performance.

In 2014 Jaiganesh, Venu, J. Dhileep Kumar, and J. Girijadevi. Proposed design of Programmable Logic Controller (PLC) operated AGV which is as below.

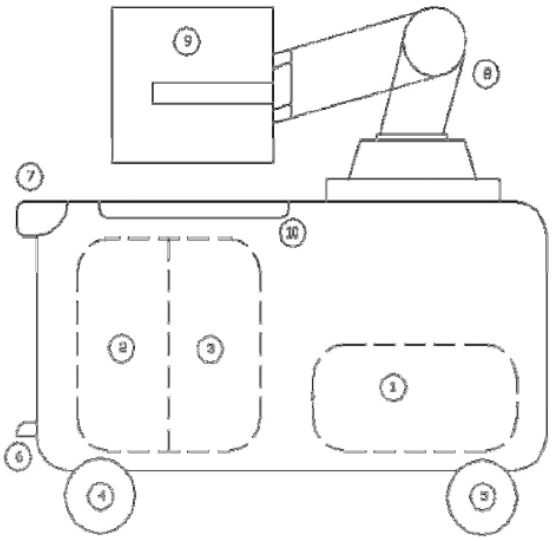

Fig. 1 PLC operated AGV [11]

This Figure above consist pats as 1. PLC operated brushless DC motor 2. PLC Components 3. Battery 4. Front wheel 5. Rear wheel 6. Proximity Sensor 7. Photo Sensor 8. Robotic Arm 9. Material to be shifted 10. Provision for accommodation of material. This AGV is controlled with PLC and it is having a robotic arm manipulator mechanism over it to automatically pick and place materials.

In 2011 Hymavathi, V., and G. Vijay Kumar have gave a double line follower AGV that follows line drawn of the floor and moves forward. They presented the mechanical constructional design and circuitry interfacing with microcontroller of AGV [12]. They also perform several running tests on the vehicle to verify the capability to follow the line by choosing the correct path and achieve the goal position. The proposed design is as follows,

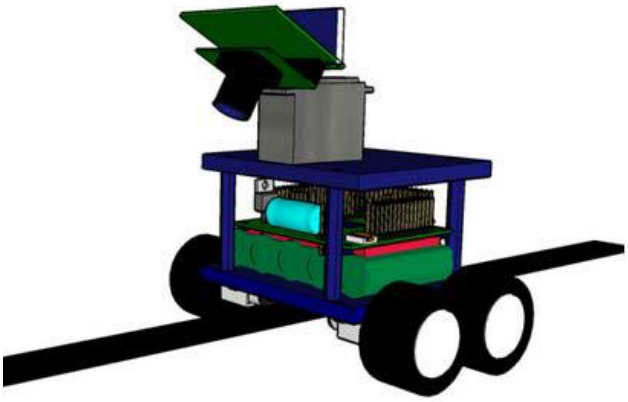

Fig. 2 Schematic of Double Line follower AGV [12]

They used IR sensors as input and motors to move vehicle in forward or in any other direction.
In 2012 Hongpeng Chi, Kai Zhan, Boqiang Shi studied a underground mining AGV that is laser targeted. The outlook of AGV is as below,

Fig. 3 Scale model of the vehicle [13]

This AGV is unique in such a way that it draws on the premise of barcode theory allowing feasible relative navigation system even without using a GPS.

In 2003 Kaloutsakis, Georgios, Nikos Tsourveloudis, and Polyhronis Spanoudakis. Studied the design of AGV that has been designed with the use of parametric technology. The size of the model was 1.2 meters long and 0.7 meter wide. Vehicle's load capacity is 200 Kg and volume capacity exceeds the 1 m3.

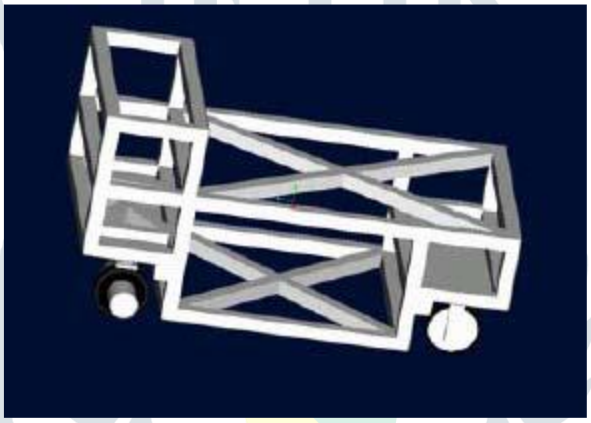

Fig. 4 Hellenak's frame design [3]

This is an Automated Guided Vehicle (AGV) of Hellenak that it is manufactured at the Machine Tools Laboratory of the Technical University of Crete [3].

In 2005 Hugo Freitas et. al presented a study on industrial AGV. This paper presents the kind of industrial sensors that can be used in an autonomous vehicles. They also presented sensors and parts position for AGV. The proposed design is as below,

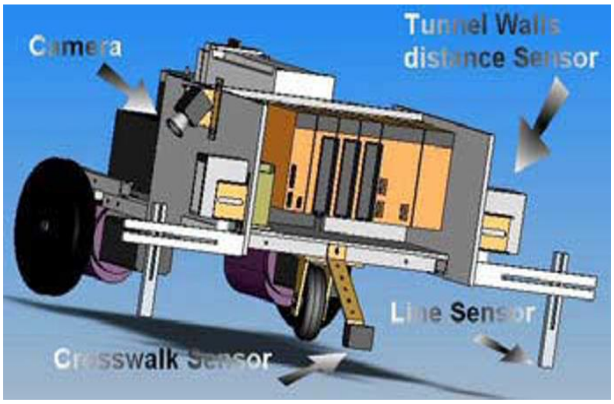

Fig. 5 AGV artistic impression [14]

In 2013 Deepak Punetha, Neeraj Kumar and Vartika Mehta described the techniques for analyzing, designing, controlling and improving the health care management system using AGV. They proposed line following AGV for heath management system. The AGV that they develop is as below,

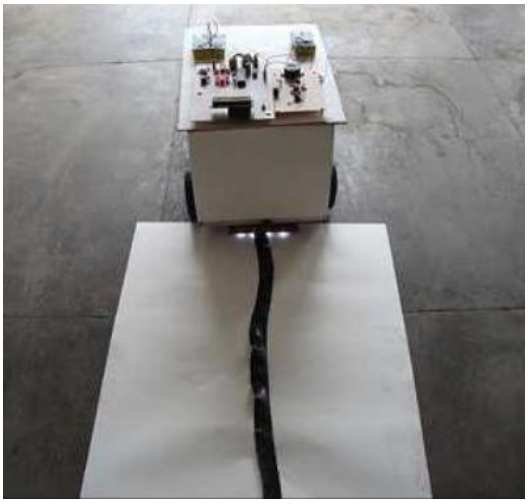

Fig. 6 line following AGV [15]

In 2013 Parikh, Priyam A. et al presented AGV that is guided by color detector automated guided vehicle. It is also called Color Guided Vehicle (CGV). The figure below shows design of Color Guided Vehicle.

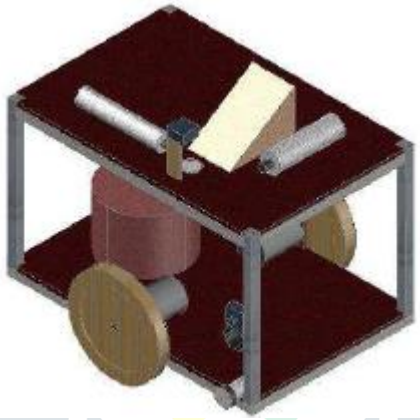

Fig. 7 Color Guided Vehicle [16]

III. CONTROL SYSTEMS

The control system of AGV totally depends on parts that are available on AGV as input elements control unit and output actuators or output elements. There are so many controllers available to use as control system of AGV. In this section we discuss parts that has been used for AGVs and altered control system by which microcontroller controls whole system. There are so many control system used to control micro controller such as ordinary Petri nets [17], ladder programming [17], Fuzzy Logic [18], Ziegler Nichols Algorithm [19-21], etc. To operate efficiently & increasing precision of AGV, the AGV should be easily controllable and task must be in well managed order. Delivery task must be allocated in a way that it helps to minimizing the waiting time while loading/unloading at stations. In the paper of kumanan [22] described the multi objective task scheduling of AGV in Flexible manufacturing environment using nontraditional optimization algorithm. The time that needs to be controlled for a typical deliver cycle system of AGV is first the Loading at the pickup station, then travel time to the drop-off station, then unloading at drop off station and finally Empty travel time. The control system by which the [11] AGV is being controlled is Robotic Logistics System. In this AGV Proximity sensors are set up in pathway to detect the vehicle movement in field and it is directly controlled as the start and stop process for the vehicle. For object detection and obstacle avoidance Photo sensors were incorporated. The controller receives signal from the sensors (transfer device) once signals received completely Microcontroller transmits signal to the driving system to move the vehicle to the next destination point. This AGV is having an automatically charged battery which powers vehicle.

The double line following AGV [12] follows two lines drawn parallel to each other. This line is sensed with two IR sensors. Differential steering is used to make turns for vehicle. In this AGV wheels are mounted in back side of vehicle this back wheel has a dedicated motor for moving while the front wheel is free to rotate. The microcontroller controls two DC motors of AGV to navigate path. This AGV have manual pick up and drop options.

The AGV that is developed by [14] have PLC as their control system. The main controller which provides a differential speed variation has a simple proportional controller that is proportional to the angle for the track. Combining all controller this AGV creates a hybrid system. Without interrupts from other sensors this hybrid system resumes vehicle on its task. If this hybrid system is interrupted by given sensors then it changes its mode of operation. This AGV have manual pick and place mode for material handling.

IV. NAVIGATION TECHNIQUES

There are so many types of navigation available for Automated Guided Vehicles such as Wired, Guide tape, Laser target navigation, Vision guidance, Geo guidance, etc. in past few years some other technique also adapted as navigation techniques. Most of the time navigation technique selection depends on the task that needs to be performed in available environment. Nowadays a common navigation technique used at service industrial environment is Guide tape and vision guidance. Out of this navigation methods some are explained.

4.1 Wired Navigation

A slot is cut in to the floor on which AGV need to move. In this cut a wire is placed around 1 inch or at measurable distance below the surface in a way that microcontroller can easily get interfaced with it. This slot is cut exactly on a way that AGV will follow. A radio (any measurable) signal is used to transmit data through this wire. According to the data received AGV moves in facility. A sensor which can detects the relative position of this signals is place on the bottom of the AGV.

4.2 Guide tape Navigation

As it names this navigation method requires tape on floor as path of AGV to navigate inside the facility. This tape can either be colored or magnetic. The sensors installed in AGV will detect this line and send signal to control system [18]. According to operation requirement and logic programming this AGV moves inside the facility. There are other way to navigate using line following technique. Such as double line following at a time for precise motion [12]. Making marks with this lines as station to start and stop is also a possible way of navigation [14, 24].

4.3 Laser target navigation

For laser target navigation the Automated Guided Vehicles carries a laser transmitter and receiver on front side or on every side of it. The laser is transmitted and the reflection is received by the same sensor. According to the signal received from this sensor microcontroller moves motors or prime movers for AGV motion in field. Such type of navigation is useful when operation like Underground mining [13, 14] required or places where GPS or other system of navigation doesn't work properly.

4.4 Vision guidance Navigation

Vision based navigation is done through either the help of camera mounted on AGV or sensors like photo sensors. In this navigation method artificial intelligence is installed in control system for receiving data from camera analyzing the data and move motors from results of data. Same navigation can be done using Computer Vision with Neural Network [27, 28]. Alternative use of this navigation is navigate according to color [16].

4.5 Other navigation methods

There are other method of navigation rather than this methods. Such as Autonomous navigation [23] this is achieved by incorporating a high degree of on-board autonomy and by decreasing the amount of manual work required that establishes the a priori knowledge of the environment. Encoder based navigation [25] this is done through encoder connected with motors of AGV and tiles that are being followed by AGV. Magnet spot guidance method [26] this is archived with magnetic spot at stations and Hall Effect sensors on AGV.

V. APPLICATION OF AGV

Main use of AGV is at places where t is require the task of material handling. There are so many industries that use AGV for human less material transport from one place to another fix place. Types of industries that may use AGV are as below.

Primary industries

Agriculture industries use light load transport AGV for dealing seeds small plats pots in farm house. It is hard to use AGV in underground mining industries due to inaccuracy of GPS system in that case laser target AGV are useful. There are few other industries where new idea of navigation and need of material handling may lead to ease in application of AGV.

Secondary industries

Secondary industries include heavy manufacturing industries, light manufacturing industries, food processing industries, oil & refining industries. These are the industries that widely use AGVs. First AGV was developed in secondary industry. Then according task requirement and environmental condition researcher proposed and developed AGV to use at other industries. Nowadays AGV are used not only in secondary industries but also primary and tertiary industries.

Tertiary industries

Tertiary industries includes healthcare such as medicals and hospitals, pharmacy, waste disposal industries and hotels & restaurants. These are the industries which are adopting AGV for many purposes. Some of this industries are already using AGVs but there is change in environment seen at every place so it needs special purpose AGVs at mostly every places.

VI. CONCLUSION

It is seen according to some researchers there are significant amount of change seen in theoretical and practical values. This variation may overcome with use of new technology of navigation and control systems. In this paper presents existing navigation techniques of AGV as well as Design of AGV which are developed or proposed by researchers. We also get information of control systems for AGV. Automated Guided vehicles are largely used at industries for material handling. Studding this paper we understand existing and some other possible application of AGV.

REFERENCES

[1] Hollier, Robert H. Automated guided vehicle systems. Springer Verlag, 1987.

[2] G. A Koff, "Basics of AGVS," in Proc. SME ULTRATECH, vol. 1, September 1986.

[3] Kaloutsakis, Georgios, Nikos Tsourveloudis, and Polyhronis Spanoudakis. "Design and development of an automated guided vehicle." IEEE International Conference on Industrial Technology, 2003. Vol. 2. IEEE, 2003.

[4] Censi, Andrea, et al. "Simultaneous calibration of odometry and sensor parameters for mobile robots." IEEE Transactions on Robotics 29.2 (2013): 475-492.

[5] Larsen, Thomas Dall, et al. "Location estimation for an autonomously guided vehicle using an augmented Kalman filter to autocalibrate the odometry." FUSION98 Spie Conference. 1998.

[6] Lee, Kooktae, and Woojin Chung. "Calibration of kinematic parameters of a car-like mobile robot to improve odometry accuracy." 2008 IEEE International Conference on Robotics and Automation. IEEE, 2008.

[7] De Cecco, Mariolino. "Self-calibration of AGV inertial-odometric navigation using absolute-reference measurements." IMTC/2002. Proceedings of the 19th IEEE Instrumentation and Measurement Technology Conference (IEEE Cat. No. 00CH37276). Vol. 2. IEEE, 2002.

[8] Song, Jong-Hwa, and Gyu-In Jee. "Kalman filter based on-line calibration of laser scanner for vehicle navigation." 2011 11th International Conference on Control, Automation and Systems. IEEE, 2011.

[9] Cucci, Davide Antonio, and Matteo Matteucci. "A Flexible Framework for Mobile Robot Pose Estimation and Multi-Sensor Self-Calibration." ICINCO (2). 2013.

[10] Kallasi, Fabjan, et al. "A novel calibration method for industrial AGVs." Robotics and Autonomous Systems 94 (2017): 75-88.

[11] Jaiganesh, Venu, J. Dhileep Kumar, and J. Girijadevi. "Automated guided vehicle with robotic logistics system." Procedia Engineering 97 (2014): 2011-2021.

[12] Hymavathi, V., and G. Vijay Kumar. "Design and implementation of double line follower robot." International Journal of Engineering Science and Technology 3.6 (2011).

[13] Chi, Hongpeng, Kai Zhan, and Boqiang Shi. "Automatic guidance of underground mining vehicles using laser sensors." Tunnelling and Underground Space Technology 27.1 (2012): 142-148.

[14] Freitas, Hugo, et al. "An industrial autonomous guided robot." IFAC Proceedings Volumes 38.1 (2005): 133-138.

[15] Punetha, Deepak, Neeraj Kumar, and Vartika Mehta. "Development and applications of line following robot based health care management system." International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) 2.8 (2013): 2446-2450.

[16] Parikh, Priyam A., Keyur D. Joshi, and Saurin Sheth. "Color Guided Vehicle–An Intelligent Material Handling Mechatronic System." Proceedings of the 1st International and 16th National Conference on Machines and Mechanisms (iNaCoMM 2013), IIT Roorkee, India. 2013

[17] Luo, Jiliang, and Huijuan Ni. "Programmable‐logical‐controllers Synthesis for Automated‐guided‐vehicle Systems Using Ordinary Petri Nets." Asian Journal of Control 16.6 (2014): 1760-1770.

[18] Parikh, Priyam, et al. "Implementing Fuzzy Logic Controller and PID Controller to a DC Encoder Motor–"A case of an Automated Guided Vehicle"." Procedia Manufacturing 20 (2018): 219-226.

[19] Parikh, P., H. Shah, and Saurin Sheth. "A Mechatronics design of a line tracker robot using Ziegler Nichols control technique for P, PI and PID controllers." International Mechanical Engineering Congress (IMEC-2014). 2014.

[20] Parikh, Priyam Anilkumar, Saurin Sheth, and Trupal Patel. "Positional Analysis of a DC Brushed Encoder Motor Using Ziegler-Nichols Algorithm." CAD/CAM, Robotics and Factories of the Future. Springer, New Delhi, 2016. 637-650.

[21] Sheth, Saurin, et al. "Automatic sorting system using machine vision." Multi-Disciplinary International Symposium on Control, Automation & Robotics. 2010.

[22] Udhayakumar, P., and S. Kumanan. "Task scheduling of AGV in FMS using non-traditional optimization techniques." International Journal of Simulation Modelling 9.1 (2010): 28-39.

[23] Martínez-Barberá, Humberto, and David Herrero-Pérez. "Autonomous navigation of an automated guided vehicle in industrial environments." Robotics and Computer-Integrated Manufacturing 26.4 (2010): 296-311.

[24] T. O. Barayyan, "IR coding design and implementation for autonomous in-door mobile robot localization," 2015 5th National Symposium on Information Technology: Towards New Smart World (NSITNSW), Riyadh, 2015, pp. 1-5

[25] Andersen, Nils, Lars Henriksen, and Ole Ravn. "Design of navigation and control for an agv." IFAC Proceedings Volumes 28.11 (1995): 175-180.

[26] Lee, Sok-Yong, and Hai-Won Yang. "Navigation of automated guided vehicles using magnet spot guidance method." Robotics and Computer-Integrated Manufacturing 28.3 (2012): 425-436.

[27] Varagul, Jittima, and Toshio Ito. "Simulation of Detecting Function object for AGV Using Computer Vision with Neural Network." Procedia Computer Science 96 (2016): 159-168.

[28] Mahaleh, Mahmoud Bakhshinejad Beigzadeh, and Seyed Abolghasem Mirroshandel. "Harmony search path detection for vision based automated guided vehicle." Robotics and Autonomous Systems 107 (2018): 156-166.